Plant Density and Environment Effects on Orchardgrass–White Clover Mixtures

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ABSTRACT

Earlier research indicated that orchardgrass (*Dactylis glomerata* L.) cultivars affected white clover (*Trifolium repens* L.) stolon structure during establishment. We conducted a field study to determine if plant density and environment modified the effect of orchardgrass cultivars on white clover. 'Dawn' and 'Pennlate' orchardgrasses were established at 10-, 20-, or 40-cm spacings in mixture with 'Will' white clover in a systematic plant spacing design. Plots were established in September 1996 on a Hagerstown, Berks, or Rayne soil in central Pennsylvania. Orchardgrass was harvested monthly from May to September 1997 and 1998 to determine yield and tiller number per plant. White clover plants were dug from each plant spacing and site in the fall to determine stolon structure. Orchardgrass cultivar did not affect white clover stolon structure. Orchardgrass and white clover plants were larger and more complex on the Hagerstown soil than on the lower fertility Berks and Rayne soils. The highest stolon densities occurred at the 40-cm plant spacing on the Hagerstown soil in 1998 with >22 m of main stolon m^{-2} along with 8 m of first-order branches and 1 m of second-order branches. On the Rayne soil, plant spacing had little effect on stolon structure. Weed competition was greater on the Rayne soil (788 plants m^{-2} from 33 species) than on the higher fertility Hagerstown soil (157 plants m^{-2} from 19 species). Interspecific competition, edaphic factors, and climate interacted to govern the structure of white clover stolons and overwhelmed orchardgrass cultivar effects.

Cool-season grass pastures predominate in grazing lands of the northeastern USA (Baylor and Vough, 1985). White clover is a critical component of mixed species pastures in this region. Through N fixation, it supplies much of the N needed for growth of itself and other species within the sward. Orchardgrass frequently is used in pastures in the Northeast because of its drought tolerance and productivity (Christie and McElroy, 1994; Van Santen and Sleper, 1996). Maintaining a productive grass–clover mixture in grazed pastures depends on the soil type, environment, plant density, and compatibility of specific grass and legume cultivars (Haynes, 1980).

Soil factors typically restrict grazing land productivity and dictate the plant community in the northeast USA. Many northeastern soils have low native soil fertility and require lime and P for adequate forage production (Vough, 1990). Soil drainage limitations range from excessively drained gravelly soils to soils with impervious subsoil layers that limit drainage. These same edaphic limitations affect growth, morphology, and persistence of grasses and legumes in grazing lands. White clover persists in grazing lands by the growth, development, and continual replacement of stolons along with some seedling recruitment (Frame et al., 1998). Soil moisture deficits reduce stolon production in white clover and tillering in grasses (Belaygue et al., 1996; Norris, 1982). Soil pH < 6.0 and low soil P also restrict stolon growth and branching in white clover and interact with water stress to limit its persistence (Singh and Sale, 1998; Bailey and Laidlaw, 1999). These abiotic stresses, along with biotic stresses of pathogens, insects, and ungulate herbivores may fragment plants into smaller, less competitive individuals and contribute to species disappearance from grazed swards.

Competition between plants is affected by plant population density (nearness and number of neighbors) and resource availability (Murphy and Briske, 1992). In dense swards, the light environment affects companion plants through changes in light quantity and in the red/far-red light ratio. As light penetrates the canopy, red light is attenuated and light at the base of the canopy is rich in far-red light. In grasses and legumes, several morphogenetic changes, such as reduced tillering (branching) and increased shoot height, are presumably mechanisms for individual plants to adapt to changes in light resource availability (Ballere et al., 1995). Thus, changes in sward structure resulting from fragmentation and loss of individuals or species can alter the light environment and further influence competitive interactions among plants.

Grass species and cultivars differ in their compatibility with legumes. Tall fescue (*Festuca arundinacea* Schreb.) cultivars reportedly differ in their compatibility with white clover (Pederson and Brink, 1988). Early maturing cultivars of perennial ryegrass (*Lolium perenne* L.) and orchardgrass were more compatible with white clover than later maturing cultivars (Gilliland, 1996; Gooding et al., 1996; Sanderson and Elwinger, 1999). On the other hand, orchardgrass lines with later maturity, reduced spring canopy height, and fewer tillers per plant were more compatible with birdsfoot trefoil (*Lotus corniculatus* L.) than were other lines (Short and Carlson, 1989).

Elucidating how environments and plants interact in grass-legume mixtures can help in developing grazing land management for stressful environments. Our earlier research indicated that orchardgrass cultivars affected the establishment of white clover (Sanderson and Elwinger, 1999). That research was conducted in the greenhouse, at one field site, and at one plant density. The objective of the current field study was to examine how orchardgrass cultivar and grass plant density affected the plant structure, yield, and competitive interactions of orchardgrass and white clover in three different environments.

MATERIALS AND METHODS

The experiment was conducted at three field sites of different soil type, fertility, and physiographic region in Pennsylvania (Table 1). These sites represent typical grazing land soils in the Ridge and Valley (Rock Springs and Port Matilda) and

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Table 1. Description of three Pennsylvania field sites used in the experiment. Rock Springs and Port Matilda are in the Ridge and Valley physiographic province. Kylertown is in the Allegheny plateau physiographic province.

Site	Elevation	Soil type	Soil depth	Available water-holding capacity†	1996 pH	1996 P	1996 K	1998 pH	1998 P	1998 K
	m		cm	cm		kg ha^{-1}‡			kg ha^{-1}	
Rock Springs	350	Hagerstown silt loam (fine, mixed, semiactive, mesic Typic Hapludalfs)	91	90	6.5	93	122	6.3	72	104
Port Matilda	300	Berks shaly silt loam (loamy-skeletal, mixed, active, mesic Typic Dystrudepts)	46	75	6.2	24	279	6.0	16	182
Kylertown	600	Rayne silt loam (fine-loamy, mixed, active, mesic Typic Hapludults)	76	95	5.6	27	190	6.2	21	87

† Available water for the specified total soil depth
‡ pH and available P and K in the surface 15 cm of soil.

Allegheny Plateau (Kylertown) physiographic provinces of the northeastern USA. The available water holding capacity of the soils is limited by soil depth and content of coarse rock fragments (25 to 75 mm in diameter; Barnes and Beard, 1997). The Berks and Rayne soils are also limited by a strongly acid subsoil. Available soil P levels in the surface 15 cm were in the optimum range for grass-legume mixtures at Rock Springs, but below optimum at the other sites. Available soil K was optimum at Port Matilda but below optimum at the other sites. Air temperature and rainfall at each site were measured with an automatic meteorological station (Campbell Scientific, Logan, UT).

Field sites were rototilled to a 15-cm depth to kill existing vegetation and prepare the sites for transplanting. Plants of orchardgrass and white clover were started from seed in the greenhouse in May 1996 and transplanted to the field in September, 1996. Dawn and Pennlate orchardgrasses were established at three densities in mixture with Will white clover. The planting arrangement of the orchardgrass at each site was a systematic design for plant spacing experiments (Nelder, 1962; Fig. 1). Plots were arranged in a wagon-wheel layout with 16 radii (spokes) and 11 plants per radius. Four plants at the center of the wheel were planted 10 cm apart, the next four plants were planted 20 cm apart, and the outside three plants were planted 40 cm apart. One-half of the spokes was transplanted to Dawn and the other half was transplanted to Pennlate orchardgrass. Dawn is a medium maturity cultivar and Pennlate is late maturing (Alderson and Sharp, 1994). These were the same cultivars used in our earlier research (Sanderson and Elwinger, 1999). Fourteen white clover plants were transplanted into each of the spaces between the grass spokes. Three replicate wheels were established at each site. Systematic designs have been used in plant spacing experiments with cool-season grasses (Asay and Johnson, 1997; Hill et al., 1991), warm-season grasses (Sanderson and Reed, 2000), and row crops (Hiebsch et al., 1995).

Orchardgrass plants were measured and harvested in May, June, July, August, and September of 1997 and 1998. An additional harvest was taken in October 1998. Measurements and harvests were done on one target plant (Fig. 1) at each spacing in three adjacent spokes per cultivar and wheel. The heights of target plants were measured from the soil to the collar of the uppermost fully expanded leaf. Grass plants were clipped at a 7.6-cm stubble height and the clipped herbage

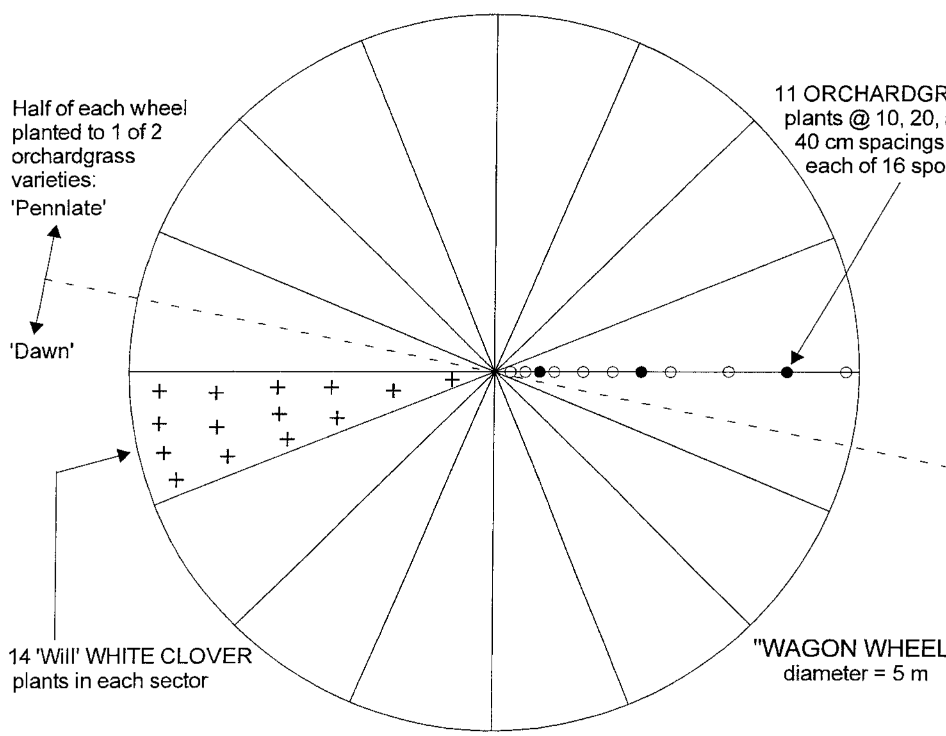

Fig. 1. Diagram of the planting arrangement and systematic plant spacing design used for the experiment. Filled circles represent the target orchardgrass plants on which measurements were made.

was dried in a paper bag at 55°C for 48 h. White clover herbage was clipped at the same height and was discarded. Tillers were counted in June, July, August, and September of 1997 and May, June, July, August, September, and October of 1998.

The amount of red and far-red light at the base of the plant canopy was measured with a Model LI-1800 spectroradiometer (Li-Cor, Lincoln, NE) before and after each harvest. Skies were clear on each day and measurements were made during 1100 to 1530 h. Measurements were taken by placing a remote cosine receptor (attached to the instrument via a fiber optic cable) at the base of the plant canopy in each spoke. The sensor was ≈1 cm above the ground because of the sensor housing. Light spectral irradiance was recorded at 2-nm increments from 400 to 750 nm. One measurement was taken at the 10-, 20-, and 40-cm spacings in each of two spokes per cultivar per wheel. The ratio of red to far-red light was calculated with the average spectral irradiances of 660 to 680 nm for red and 720 to 740 nm for far-red.

In October of 1997 and 1998, white clover stolons were dug from each plant density within one sector from each grass cultivar and wheel for stolon structure analysis. A 0.03-m^2 area was dug from the 10-cm spacing, a 0.2-m^2 area from the 20-cm spacing, and a 0.6-m^2 area from the 40-cm spacing. Soil was washed from the stolons in cold water. The roots and petioles were removed and discarded. Stolons were separated into main (parent) stolons, first-order branches (branches from the main stolon), and second-order branches (branches on first-order branches). No third-order branches were observed. The number, total length, and dry mass of each stolon class was determined. All stolon data were expressed on a unit-area basis.

In October 1998, all other plants including weedy species were identified in the wheels at each site to determine what other species were competing with the orchardgrass and white clover. All other plant species present in the sod piece from which stolons were separated, were identified, counted, and dried at 55°C for 48 h.

Separate analyses of variance were conducted for data from each year. The experimental design was equivalent to a randomized complete block experiment with a split-block treatment arrangement, since, following Nelder (1962) and Milne (1959), the sampling can safely be treated as random. The MIXED procedure of SAS (1998) was used to model the responses, with blocks (nested in locations), and the three error terms containing blocks treated as random effects. Regression effects for responses to spacing were tested with a set of orthogonal polynomial contrasts including interactions with sites. If the linear × site effect was significant, then differences among sites were assessed by analysis of variance on estimated regression parameters for each experimental unit, followed by tests of the pair-wise differences between the mean regression parameters (equivalent to a Fisher's least significant difference test).

RESULTS

Temperature and Rainfall at Each Site

Temperatures were near the long-term average at all three sites in 1997, whereas 1998 was a warmer year than normal (Table 2). The Kylertown site was about 1°C lower in temperature than the other sites. Rainfall during spring and early summer of 1997 was below the long-term average at all three sites. In 1998, rainfall was above average in spring and early summer, whereas rainfall later in the season was below the long-term average at each site. Rock Springs had ≈100 mm more rainfall during the growing season than the other sites. Port Matilda and Kylertown had similar amounts of growing season rainfall.

Grass Yield

The dry matter yield of orchardgrass plants increased with wider plant spacing at each site in each year (Fig. 2). Except for Kylertown in 1998, these yield responses (slope of the regression line) were significant ($P < 0.05$). A slope × site interaction ($P < 0.05$), however, indicated that the magnitude of increase differed among sites. Dry matter yield was lowest and increased very little with plant spacing at Kylertown. The Rock Springs and Port Matilda sites did not differ ($P > 0.05$) in yield response in 1997; however, in 1998, yields and yield response to plant spacing were much greater at Rock Springs than at Port Matilida. There was no significant difference between Pennlate or Dawn orchardgrass in dry matter yield; however, Pennlate had a greater number of tillers per plant than Dawn in 1998 (data not shown).

Tillers per plant generally explained most of the dif-

Table 2. Average monthly air temperature and total monthly rainfall at the three experimental sites in Pennsylvania.

	Port Matilda		Kylertown			Rock Springs		
Month	1997	1998	1997	1998	30-yr avg†	1997	1998	30-yr avg
	Temperature, °C							
April	7.8	10.4	6.8	9.1	7.1	7.6	10.0	8.7
May	12.0	17.1	11.1	16.1	12.8	11.9	17.0	14.8
June	19.2	18.5	18.3	17.6	17.2	19.4	18.5	19.5
July	20.9	20.7	19.8	19.9	19.4	20.9	20.7	21.8
August	18.9	21.0	18.2	20.4	18.5	19.1	20.9	20.9
September	15.8	19.0	14.7	17.7	14.6	15.4	18.6	16.8
October	10.5	11.4	9.6	10.1	8.9	10.2	10.7	10.6
	Rainfall, mm							
April	24	180	27	168	74	28	172	74
May	103	107	87	101	97	100	116	92
June	54	93	66	56	114	59	131	101
July	61	47	48	25	104	61	89	91
August	120	45	116	75	89	171	71	80
September	85	28	103	44	94	122	44	82
October	15	48	12	77	77	13	20	72
Total	462	548	459	546	991	554	643	947

† Long-term data apply to both Port Matilda and Kylertown. Data for the 30-yr average are from Waltman et al. (1997).

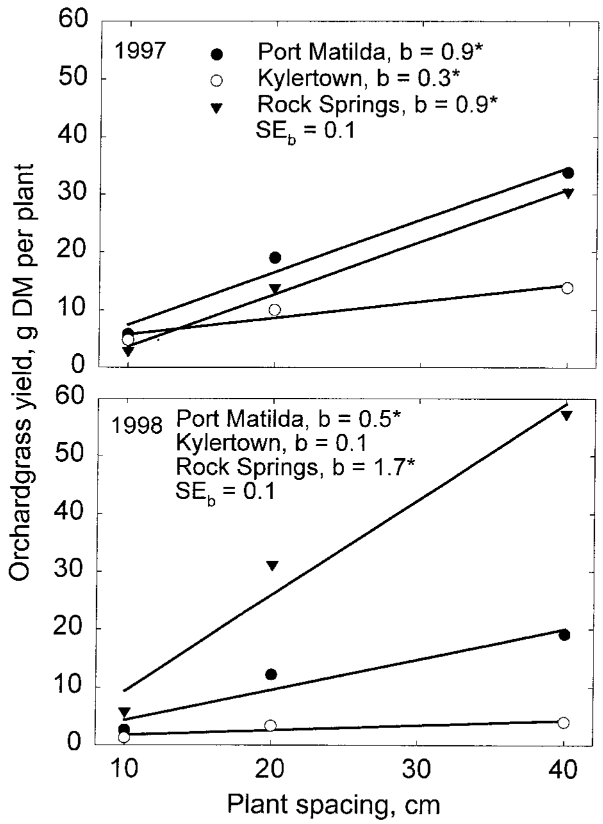

Fig. 2. Yield of dry matter (DM) per plant for orchardgrass in 1997 and 1998 at three locations in Pennsylvania in response to plant spacing. Data points are averages of two cultivars and three replications with three radii per replicate. In 1997, slopes (b values) did not differ between Port Matilda and Rock Springs, whereas the slope for Kylertown was less ($P < 0.05$). In 1998, slopes for all locations differed. Asterisks indicate that slopes are different ($P <$ 0.05) than zero.

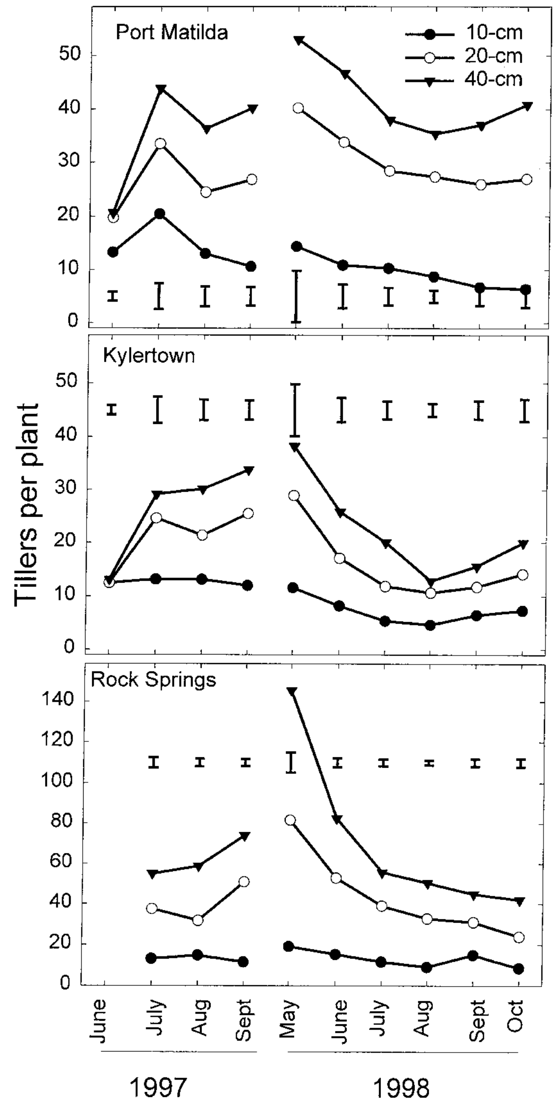

Fig. 3. Number of tillers per plant for orchardgrass in 1997 and 1998 at three locations in Pennsylvania in response to plant spacing. Data points are averages of two cultivars and three replications with three radii per replicate. Note different scale for the *y* axis of Rock Springs panel. Bars indicate one standard error.

ferences in dry matter yield among sites and plant spacings (Fig. 3). Similar to the pattern for yield, orchardgrass tillered more ($P < 0.05$) with greater plant spacing and plants at Rock Springs had more ($P < 0.05$) tillers than at other sites. The number of tillers per plant at the 20- and 40-cm spacings increased from May 1997 until May 1998. Plants at the 10-cm spacing maintained only ≈10 tillers per plant throughout both years at each site. The flush of tillers in May 1998 probably reflects the growth of tillers initiated in the fall and the above average rainfall (Table 2). The decrease in tillers during summer may have resulted from late-formed tillers that may not have been able to develop functional roots. When new tillers form, they obtain water via the parent plant until they develop functional adventitious roots (Ong, 1978). If the root system does not develop, then the tillers will die. Rainfall during the summer and fall of 1998 was below normal at each site (Table 2) and may have contributed to the decrease in tillers per plant.

White Clover Stolon Structure

White clover plants remained small and of simple structure during 1997 (Fig. 4, 5). There were <25 main stolons and first-order branches per square meter and almost no second-order branches at any site in 1997. Site and plant spacing affected the length and branching of stolons. In 1997, sites did not differ in stolon response to grass plant spacing. In 1998, white clover plants at the Rock Springs site had longer ($P < 0.05$) stolons of all branching orders at the 40-cm spacing than at the other sites. Stolons were longer, more numerous, and more highly branched at greater spacings between grass plants than at narrow spacings.

In both 1997 and 1998, stolon structure was similar when grown with either Dawn or Pennlate orchardgrass (data not shown). White clover stolons were more numerous, larger, and complex in 1998 than in 1997 (Fig. 4, 5). At Rock Springs, there was a three- to four-fold increase ($P < 0.05$) in the number of main stolons along with first-order branches as spacing between grass plants increased. The highest stolon densities occurred at the 40-cm plant spacing at Rock Springs in 1998, where

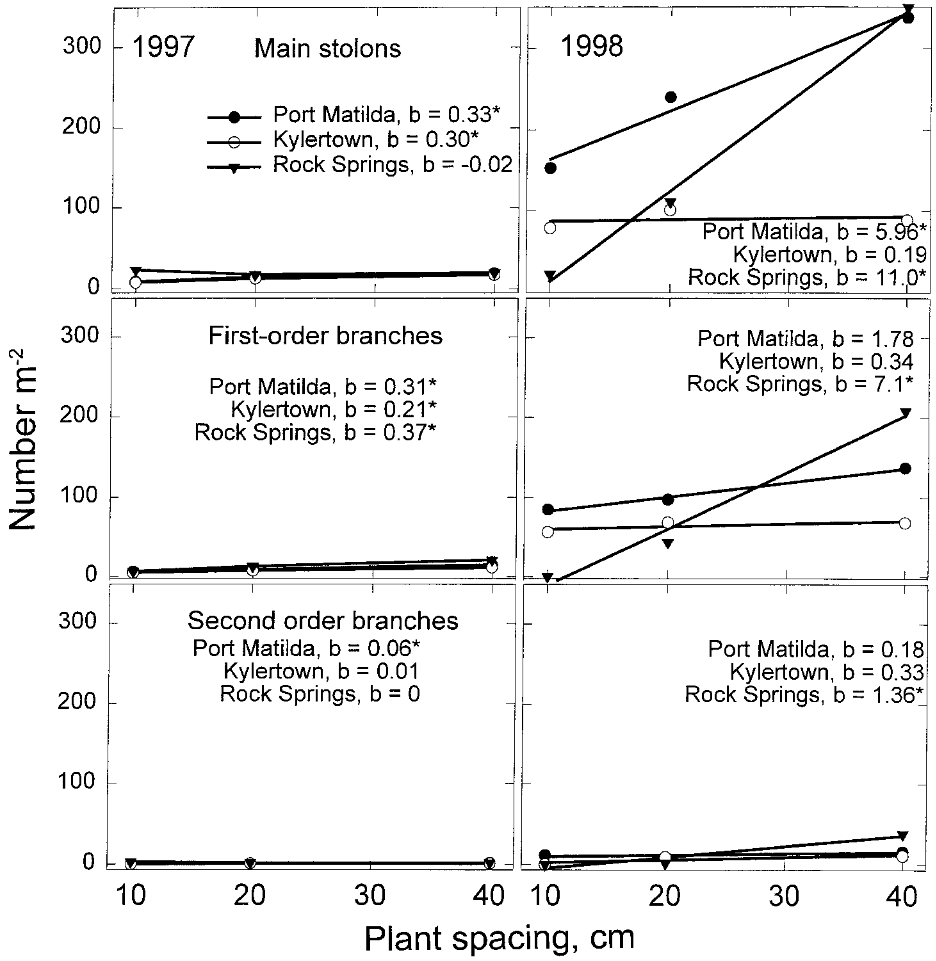

Fig. 4. Number of white clover primary stolons and stolon branches in 1997 and 1998 at three locations in Pennsylvania in response to plant spacing. Data points are averages of two orchardgrass cultivars and three replications with two radii per replicate. There were no differences ($P < 0.05$) in slopes (b values) among locations in 1997. In 1998, slopes for the response of main stolons differed among locations. The slopes for the response of first- and second-order stolons at Rock Springs differed from those of Port Matilda and Kylertown in 1998. Asterisks indicate that slopes are different ($P < 0.05$) than zero.

there was >22 m of main stolon m^{-2} along with 8 m of first-order branches and 1 m of second-order branches. At Kylertown, plant spacing had little effect on the number and length of stolons in either year.

White clover plants at the high grass density (near the center of the wheel) at Port Matilda and Kylertown had more stolons that were longer and more highly branched than at Rock Springs in 1998. White clover plants at Rock Springs, however, dramatically increased in number, size, and complexity at the 40-cm grass spacing. Compared with the Kylertown site, white clover plants at the 40-cm spacing at Rock Springs had more than three times the number and length of main stolons and branches. This may have resulted from shading and a lower red/far-red light ratio at the base of the grass canopy at the Rock Springs site (Fig. 6) because of a greater grass tiller density. Red/far-red light ratios were lowest at the narrow grass spacings and lowest at Rock Springs compared with other sites (Fig. 6).

Competition from weeds was greater at Kylertown than other locations and increased as the canopy became more open (i.e., the red/far-red light ratio increased; Fig. 6, 7). The weed mass at Kylertown ranged from 100 to 250 g m^{-2}, whereas weed mass at the other sites was <120 g m^{-2}. The low fertility of the Kylertown site probably was not able to support vigorous growth of orchardgrass and white clover, but weedy plant species adapted to lower soil fertility levels were able to thrive. The greater weed competition at Kylertown probably limited white clover growth and development. Dandelion (*Taraxacum officinale* Webber in Wiggers) and quackgrass [*Elytrigia repens* (L.) Desv. ex Nevski] dominated (82% of the number of weedy plants) the weed population at Rock Springs, whereas common yellow wood sorrel (*Oxalis stricta* L.) dominated (53% of plants) at Port Matilda. At Kylertown, quackgrass and thymeleaf speedwell (*Veronica serpyllifolia* L.) accounted for 48% of the weedy plants (Table 3). Oldfield cinquefoil (*Potentilla simplex* Michx.) and oxeye daisy [*Chrysanthemum leucanthemum* L. (= *Leucanthemum vulgare* Lam.)] were also abundant at Kylertown.

DISCUSSION

With few exceptions, there was no effect of orchardgrass cultivars on clover stolon size and structure.

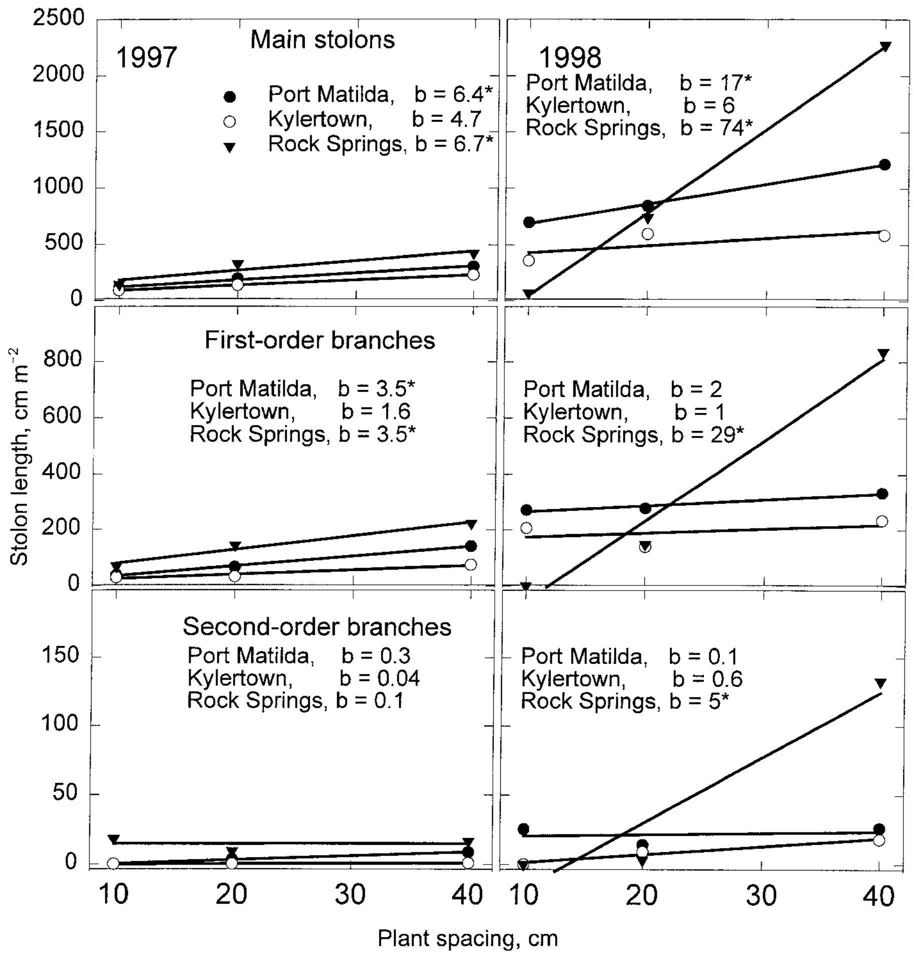

Fig. 5. Length of white clover primary stolons and stolon branches in 1997 and 1998 at three locations in Pennsylvania in response to plant spacing. Data points are averages of two orchardgrass cultivars and three replications with two radii per replicate. There were no differences ($P < 0.05$) in slopes (b values) among locations in 1997. The slopes for the response of main stolons and first- and second-order branches at Rock Springs differed from those of Port Matilda and Kylertown in 1998. Asterisks indicate that slopes are different ($P < 0.05$) than zero.

The exceptions were a slightly greater number of primary and tertiary stolons on white clover grown with Pennlate orchardgrass at the low plant densities in 1997. Late maturity in orchardgrass has been associated with increased compatibility with birdsfoot trefoil in established stands (Short and Carlson, 1989). In previous research, we found that stolon and leaf mass of Will white clover was greater when grown in mixture with Dawn rather than with Penlate orchardgrass during the establishment phase (Sanderson and Elwinger, 1999). The current study suggests that these differences may not be expressed in established stands in stressful environments.

Complex interactions among soil conditions, canopy structure, and climate resulted in different patterns of white clover stolon structure among sites. On the fertile Rock Springs site with adequate soil moisture, orchardgrass at high plant density was less limited in growth and competed strongly with white clover, mainly for light, resulting in fewer and smaller white clover plants. Changes in plant canopy structure that increase shading (a lower quantity of light and a reduced red/far-red light ratio) of clover generally increase petiole and stolon length and reduce branching (Frame et al., 1998, p. 27–28). Clover plants were most numerous at the low grass plant density where the open grass canopy resulted in a more favorable light environment and released white clover from competition for light. This allowed the white clover to vigorously explore and exploit soil resources.

On the less productive sites at Kylertown and Port Matilda, white clover plants were uniformly distributed among the different grass plant densities (Fig. 4, 5). This probably resulted from the limited orchardgrass growth and an open canopy at all densities, which allowed more light to penetrate (Fig. 6). The open canopy and lower soil fertility resulted in greater weed competition (Fig. 7). The combination of greater competition with weeds and low soil fertility severely restricted white clover stolon growth, size, and complexity.

Structure of orchardgrass and white clover plants reflected site productivity. In general, grass and clover were larger and more complex at Rock Springs, followed by the Port Matilda site, and the Kylertown site. The Kylertown site generally was ≈1°C cooler than the Port Matilda site each year. Although the Berks soil at the Port Matilda site was shallow and had low available water, the combination of low soil pH and P, along

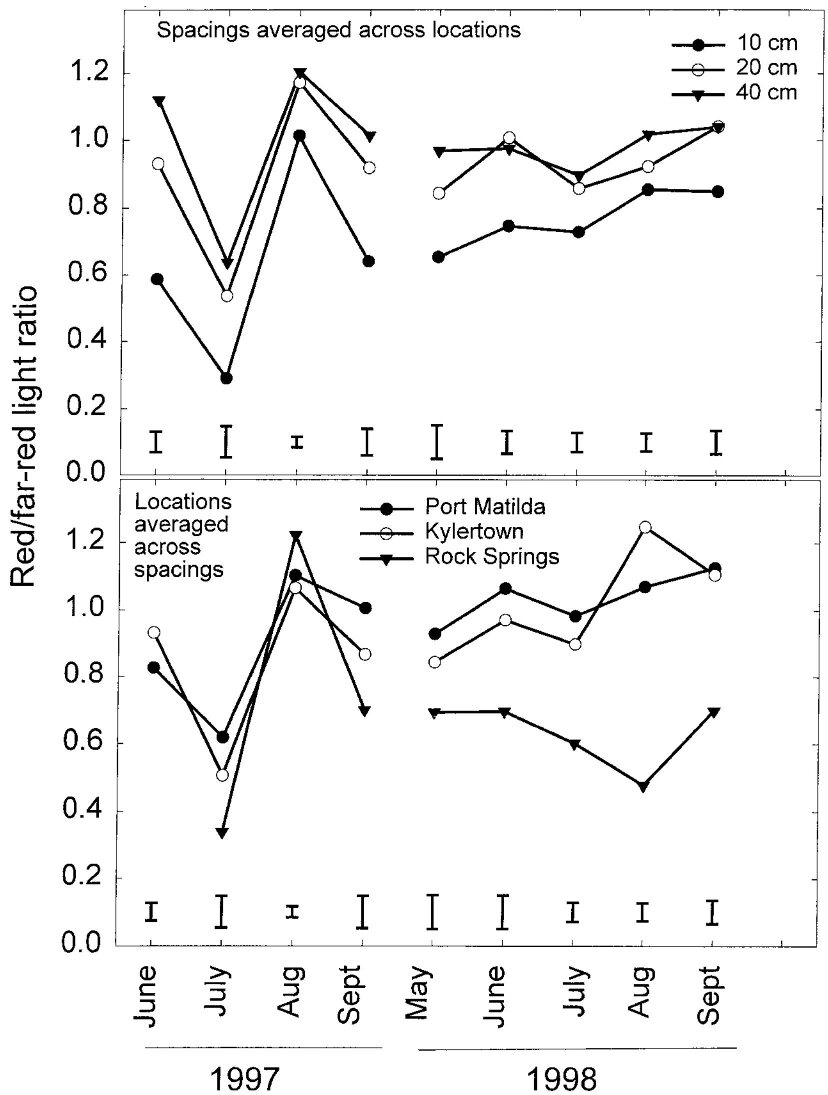

Fig. 6. Ratio of red/far-red light at the base of the plant canopy. Top: red/far-red light ratio at three plant spacings averaged across locations, two orchardgrass cultivars, three replications, and two radii per replicate. Bottom: red/far-red light ratio at three sites averaged across two orchardgrass cultivars, three plant spacings, three replications, and two radii per replicate. Bars indicate one standard error.

with a slightly lower air temperature, probably limited orchardgrass and white clover growth more on the Rayne soil at Kylertown. Low soil P reduces rooting, branching, and persistence of white clover stolons (Singh and Sale, 1997; Singh et al., 1997; Bailey and Laidlaw, 1999). Low pH along with dry soil conditions also severely limits persistence of white clover. Management to maintain a greater length and mass of stolons aids persistence and competitiveness of white clover (Nurjaya and Tow, 2001).

Water deficit stress resulting from lower rainfall and shallower soil with a lower water-holding capacity at Port Matilda and Kylertown compared with Rock Springs probably contributed to reduced stolon growth as well. Controlled environment studies showed that water-deficit stress reduced the number of stolons in white clover by inhibiting branching (Belaygue et al., 1996). Moisture stress was the most limiting factor to long-term white clover persistence in a 30-yr Australian study (Hutchinson et al., 1995).

Weedy plant species were more abundant at the lowest fertility site and competed with the orchardgrass and white clover. Soil physical and chemical limitations at Kylertown probably created canopy gaps that were colonized by weedy plant species adapted to low fertility, stressful sites. Other ecological research has shown that low-fertility soils often support the greatest number of plant species (Huston, 1993). As soil fertility declines in grassland, plant productivity decreases, resulting in reduced competition for light. The open canopy allows species adapted to nutrient-poor conditions (i.e., weeds) to replace plant species that dominate under nutrient-rich conditions (e.g., orchardgrass, white clover; Olff and Bakker, 1991).

Dandelion dominated (58% of the number of plants) the weed population at Rock Springs, a site with adequate level of soil K (Tables 1, 3). Dandelion was a small component (1% of plants) at Port Matilda, the site with the highest soil K level. On the Kylertown site, with the lowest soil K, dandelion abundance was also

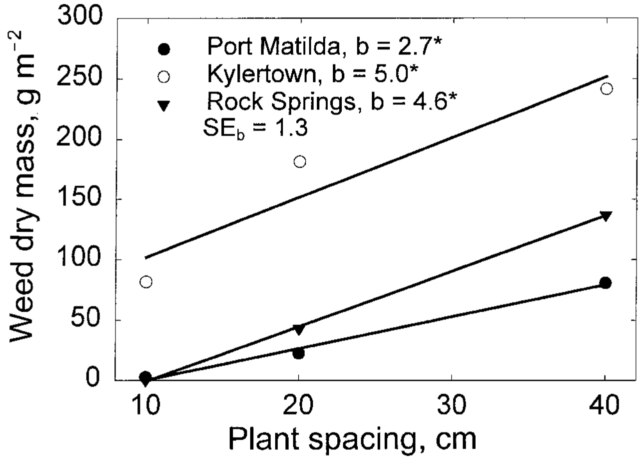

Fig. 7. Dry mass of weedy plant species present at three plant spacings at each location in the fall of 1998. Data are averages of two orchardgrass cultivars and three replicates. The slopes for Rock Springs and Kylertown were similar, but differed from those of Port Matilda. Asterisks indicate that slopes are different ($P < 0.05$) than zero.

relatively low (6% of plants). This does not fit the pattern suggested by Tilman et al. (1999) that high abundance of dandelion is associated with high levels of soil K. In our study, other soil limitations and the amount of open canopy, regardless of soil K, may have allowed dandelion seedlings to establish and thrive.

CONCLUSIONS

Interspecific competition, edaphic factors, and climate interact to govern the number, size, and structure of white clover stolons and tend to overwhelm orchardgrass cultivar effects. On productive soils, management should focus on controlling the height of the grass canopy to enable the white clover to compete for light and maintain a productive stolon population. On less productive soils, management should address amendments to improve fertility when economically feasible. Soil physical limitations, however, such as excessive drainage or shallow soil with low water-holding capacity, may limit plant responses to amendments. Therefore, management of grass–clover mixtures on these sites should focus on choosing adapted cultivars and reducing weed pressure so that bare soil and canopy gaps can be colonized by white clover stolons.

ACKNOWLEDGMENTS

The authors thank John Everhart, Agricultural Science Technician, for his skilled assistance.

Table 3. Other plant species identified at each experimental site in fall 1998.

Species	No. m^{-2}	Species	No. m^{-2}	Species	No. m^{-2}
Port Matilda		Kylertown		Rock Springs	
Oxalis stricta L.	82	*Elytrigia repens* (L.) Desv. ex Nevski	189	*Taraxacum officinale* Webber in Wiggers	141
Plantago lanceolata L.	17	*Veronica serpyllifolia* L.	187	*Elytrigia repens* (L.) Desv. ex Nevski	79
Digitaria sanguinalis L. Scop.	17	*Potentilla simplex* Michx.	86	*Oxalis stricta* L.	12
Elytrigia repens (L.) Desv. ex Nevski	10	*Chrysanthemum leucanthemum* L. (= *Leucanthemum vulgare* Lam.)	56	*Panicum miliaceum* L.	11
Setaria glauca (L.) P. Beauv. [= *Pennisetum glaucum* (L.) R. Br.]	8	*Taraxacum officinale* Webber in Wiggers	44	*Veronica serpyllifolia* L.	5
Dactylis glomerata L.	5	*Poa pratensis* L.	35	*Cerastium vulgatum* acut. [= *C. fontanum* subsp. *vulgare* (Hartm.) Greuter & Burdet]	5
Daucus carota L.	5	*Veronica officinalis* L.	25	*Digitaria sanguinalis* L. Scop.	2
Festuca arundinacea Schreb.	3	*Fragaria virginiana* Mill.	22	*Bromus secalinus* L.	2
Taraxacum officinale Webber in Wiggers	2	*Linaria vulgaris* Mill.	17	*Bromus inermis* Leyss.	1
Poa pratensis L.	1	*Hieracium pratense* Tausch (= *H. caespitosum* Dumort.)	16	*Panicum capillare* L.	1
Digitaria ischaemum (Schreb. ex Schweigg.) Schreb. ex Muhl.	1	*Achillea millefolium* L.	15	*Veronica officinalis* L.	1
Brassica kaber (DC.) L.C. Wheeler (= *Sinapis arvensis* subsp. *arvensis*)	1	*Plantago lanceolata* L.	15	*Poa pratensis* L.	1
Stellaria media (L.) Vill.	1	*Bromus tectorum* L.	11	*Aster pilosus* Willd.	1
Plantago major L.	1	*Potentilla simplex* Michx.	10	*Setaria glauca* (L.) P. Beauv. [= *Pennisetum glaucum* (L.) R. Br.]	1
Trifolium pratense L.	1	*Plantago major* L.	10	*Plantago major* L.	1
Panicum clandestinum L.	1	*Solidago canadensis* L.	7	*Medicago lupulina* L.	1
Panicum capillare L.	1	*Lotus corniculatus* L.	6	*Panicum dichotomiflorum* Michx.	1
		Digitaria sanguinalis L. Scop.	5	*Solanum carolinense* L.	1
		Sida spinosa L.	5	*Phleum pratense* L.	1
		Bromus secalinus L.	5		
		Anthoxanthum odoratum L.	5		
		Oxalis stricta L.	2		
		Daucus carota L.	2		
		Trifolium pratense L.	2		
		Erigeron strigosus Muhl. *ex* Willd.	2		
		Setaria glauca (L.) P. Beauv. [= *Pennisetum glaucum* (L.) R. Br.]	2		
		Aster pilosus Willd.	1		
		Rumex acetosella L.	1		
		Dactylis glomerata L.	1		
		Medicago lupulina L.	1		
		Bromus inermis Leyss.	1		
		Panicum capillare L.	1		
		Trifolium hybridum L.	1		

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